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## Original Contribution

# Socioeconomic Status in Relation to the Risk of Ovarian Cancer in African-American Women: A Population-Based Case-Control Study

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We investigated the association between socioeconomic status and ovarian cancer in African-American women. We used a population-based case-control study design that included case patients with incident ovarian cancer ($n = 513$) and age- and area-matched control participants ($n = 721$) from 10 states who were recruited into the African American Cancer Epidemiology Study from December 2010 through December 2014. Questionnaires were administered via telephone, and study participants responded to questions about several characteristics, including years of education, family annual income, and risk factors for ovarian cancer. After adjustment for established ovarian cancer risk factors, women with a college degree or more education had an odds ratio of 0.71 (95% confidence interval (CI): 0.51, 0.99) when compared with those with a high school diploma or less ($P$ for trend = 0.02); women with family annual incomes of $75,000 or more had an odds ratio of 0.74 (95% CI: 0.47, 1.16) when compared with those with incomes less than $10,000 ($P$ for trend = 0.055). When these variables were dichotomized, compared with women with a high school diploma or less, women with more education had an adjusted odds ratio of 0.72 (95% CI: 0.55, 0.93), and compared with women with an income less than $25,000, women with higher incomes had an adjusted odds ratio of 0.86 (95% CI: 0.66, 1.12). These findings suggest that ovarian cancer risk may be inversely associated with socioeconomic status among African-American women and highlight the need for additional evidence to more thoroughly characterize the association between socioeconomic status and ovarian cancer.

case-control studies; education; ethnicity; income; ovarian cancer; race; socioeconomic status

Abbreviations: AACES, African American Cancer Epidemiology Study; CI, confidence interval; OR, odds ratio; SES, socioeconomic status.

Lower socioeconomic status (SES) is associated with higher risk of most—but not all—types of malignancy (1). Breast cancer is a notable example for which the opposite holds true; that is, higher SES is associated with higher breast cancer risk (1, 2). Viewed simplistically, the higher breast cancer risk associated with higher SES may be relevant to ovarian cancer because both ovarian and breast cancer are hormonally linked cancers with risk associated with several reproductive characteristics, including earlier onset of menarche, later age at menopause, and decreased parity (2, 3). Of course, this comparison becomes more complex when differences in risk factor profiles are considered; for example, alcohol drinking is a risk factor for breast cancer but not ovarian cancer (2, 3). Nevertheless, a common explanation for higher SES being a marker of higher breast cancer risk is that this reflects an indirect relationship, with higher SES linked with an adverse risk profile based on the tendency for many of the risk-related reproductive characteristics to be more heavily concentrated in women of higher SES (1, 2). This SES differential likely contributes to the differential pattern of breast cancer incidence

rates in the United States by racial/ethnic group, with age-adjusted incidence rates in women being 8% higher in non-Hispanic whites than in African Americans (4); for ovarian cancer, this racial differential is even larger (26%) (4).

A clear-cut picture has not emerged from the relatively small number of prior studies in which the association between SES and ovarian cancer risk was reported (3). Two studies in the United States relied on aggregate population-level data; people who lived in neighborhoods with higher SES had higher age-adjusted rates of ovarian cancer incidence in Los Angeles, California (5), whereas in Cook County, Illinois, lower neighborhood SES was associated with a higher likelihood of adverse tumor characteristics, such as higher grade and later stage, that are associated with more aggressive disease (6). The prior case-control and cohort studies in which the association between individual-level indices of SES and ovarian cancer have been reported are summarized in Table 1 (7–14). The associations observed in case-control studies have been heterogeneous and rarely statistically significant, but in the lone US study, a strong inverse association was seen between educational level and ovarian cancer risk; that study was also the only population-based case-control study (10). In a prospective European cohort study, educational level was inversely associated with ovarian cancer risk (14), whereas in a US study, the relative risk when comparing the highest educational level with the lowest was 1.52 and was not statistically significant (13). In another prospective study in which ovarian cancer mortality was the outcome, educational level was significantly inversely associated with the risk of death from ovarian cancer in premenopausal but not postmenopausal women (12).

This synopsis of the existing evidence highlights some key points. First, the current evidence base for the relationship of SES with ovarian cancer is limited. Second, there is a paucity of US studies, and none include data for African-American women. Third, most of the prior case-control studies were hospital-based, had small sample sizes, and did not thoroughly account for the potential influence of confounding factors. Given the limited data and the heterogeneous results to date, the relationship between SES and ovarian cancer risk clearly remains unsolved. The present study was initiated to attempt to achieve greater resolution of the question of whether SES is associated with ovarian cancer risk within an ongoing population-based, case-control study of African-American women.

## METHODS

The African American Cancer Epidemiology Study (AACES) is an ongoing multisite study that was initiated to investigate factors associated with ovarian cancer in African-American women in the following 10 states: Alabama, Georgia, Louisiana, Michigan, New Jersey, North Carolina, Ohio, South Carolina, Tennessee, and Texas. The methods for AACES have been reported in detail elsewhere (15). This population-based, case-control study consisted of case patients with incident ovarian cancer ($n = 513$) and frequency-matched control participants ($n = 721$). The participants were recruited during the first 4 years of AACES (from December 2010 through December 2014), with approval from the human investigation committees at each study site.

Participation was limited to women who had a level of English language comprehension that would permit them to understand and complete the interview. To be eligible for participation, case patients had to meet the following criteria: 1) be newly diagnosed with a histologically confirmed invasive epithelial ovarian cancer; 2) reside in 1 of the geographically defined study regions; 3) self-identify as African American; and 4) be 20–79 years of age. A centralized pathology review was conducted at Duke University by the study pathologist for all cases. The cases were identified through rapid case ascertainment systems based in state cancer registries, Surveillance, Epidemiology and End Results (SEER) registries, or the cancer registries at individual hospitals within the defined geographic region. Physician consent was obtained prior to contacting the potential case participants.

Random-digit dialing using both landline and cellular telephone exchanges was used to select control participants who met the following eligibility criteria: 1) female; 2) no prior diagnosis of ovarian cancer; 3) resident of geographically defined study regions; 4) self-identified as African American; 5) 20–79 years of age; and 6) no history of bilateral oophorectomy. Controls were frequency matched to cases by age (using 5-year groupings) and state of residence. The cooperation rate for potential participants who were actually contacted was 67% among ovarian cancer case patients and 72% among controls (12).

After participants provided informed consent, study staff administered a questionnaire via a computer-assisted telephone interview. The questionnaire included detailed questions on sociodemographic and lifestyle characteristics and established ovarian cancer risk factors from categories that included hormone use, family history of cancer, reproductive history, and medical history, with a focus on reproductive and gynecologic disorders. The questionnaire also included years of education and family annual income as the measures of SES that served as the primary independent variables used in this report.

### Measurement

Measures of SES used in this study were educational level and income. Educational level was categorized as high school diploma or less, some education after high school but less than a college degree, or a college degree or more. Income was categorized as a family annual income of<$10,000, $10,000–$24,999, $25,000–$49,999, $50,000–$74,999, or ≥$75,000. For subgroup analyses, these variables were dichotomized to avoid the small stratum sizes that would result from use of these multiple categories; educational level was classified as a high school diploma or less versus at least some college education, and income was classified as less than versus greater than or equal to $25,000.

### Data analyses

The associations of educational level and income with ovarian cancer were assessed using logistic regression. We first analyzed each singly and then conducted mutually adjusted analyses. Initial models were adjusted for age and study site, followed by the additional inclusion of the following ovarian cancer risk factors that were identified a priori to

**Table 1.** Summary of Case-Control and Cohort Studies of Socioeconomic Status and Ovarian Cancer

| First Author, Year (Reference No.) | Location | No. of Cases | No. of Controls | SES Measurement | OR | 95% CI | Adjustments/Comments |
|---|---|---|---|---|---|---|---|
| Case-control studies | | | | | | | |
| La Vecchia, 1992 (7) | Milan, Italy | 742 | 3,625 | Years of education | | | Adjusted for age |
| | | | | <7 | 1.0 | Referent | |
| | | | | 7–11 | 0.9 | 0.8, 1.1 | |
| | | | | ≥12 | 0.9 | 0.7, 1.2 | |
| Tavani, 1993 (8) | Milan, Italy | 194 | 710 | Years of education | | | Unadjusted. Same study population as in LaVecchia et al. but limited to women younger than 45 years |
| | | | | <7 | 1.0 | Referent | |
| | | | | 7–11 | 1.1 | 0.8, 1.7 | |
| | | | | ≥12 | 1.6 | 1.0, 2.3 | |
| | | | | Head of household occupation status | | | |
| | | | | Low | 1.0 | Referent | |
| | | | | Middle | 1.2 | 0.8, 1.7 | |
| | | | | High | 1.8 | 1.1, 3.0 | |
| Dosemeci, 1993 (9) | Istanbul, Turkey | 49 | 244 | Occupational level | | | Adjusted for age and smoking status |
| | | | | Low | 0.5 | 0.1, 4.6 | |
| | | | | Middle | 0.7 | 0.1, 5.0 | |
| | | | | High | 1.0 | Referent | |
| Tung, 2005 (10) | Hawaii and Los Angeles, California | 558 | 607 | Years of education | | | Adjusted for age, ethnicity, oral contraceptive pill use, parity, and tubal ligation |
| | | | | <13 | 1.0 | Referent | |
| | | | | 13–14 | 0.75 | 0.55, 1.02 | |
| | | | | 15 | 0.63 | 0.41, 0.96 | |
| | | | | ≥16 | 0.59 | 0.41, 0.83 | |
| Gazibara, 2013 (11) | Belgrade, Serbia | 80 | 160 | Years of education | | | Adjusted for age and area of residence |
| | | | | ≤12 | 1.0 | Referent | |
| | | | | ≥13 | 1.4 | 0.8, 2.5 | |
| | | | | Employed | | | |
| | | | | No | 1.0 | Referent | |
| | | | | Yes | 0.7 | 0.4, 1.2 | |

**Table continues**

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**Table 1.** Continued

| First Author, Year (Reference No.) | Location | No. of Cases | Cohort Size | SES Measurement | RR | 95% CI | Adjustments/Comments |
|---|---|---|---|---|---|---|---|
| Cohort studies | | | | | | | |
| Lund, 1992 (12) | Norway | 2,517 | 800,814 | Years of education | | | Uncertain if unadjusted; 15-year follow-up, mortality outcome. Results were presented for premenopausal women; no numerical results were reported for postmenopausal women, but "no effect" was described in the text. |
| | | | | ≤12 | 1.0 | Referent | |
| | | | | ≥13 | 0.5 | 0.3, 0.9 | |
| Mink, 1996 (13) | Iowa | 97 | 207,490 | Level of education | | | Adjusted for age |
| | | | | Less than high school | 1.0 | Referent | |
| | | | | High school graduate | 0.79 | 0.45, 1.37 | |
| | | | | Vocational/some college | 0.84 | 0.46, 1.54 | |
| | | | | College graduate or more | 1.52 | 0.81, 2.82 | |
| Lahmann, 2010 (14) | EPIC Cohort, Europe[a] | 576 | 215,330 | Level of education | | | Unadjusted relative risk calculated from tabular data |
| | | | | None/primary school | 1.0 | Referent | |
| | | | | Primary school or more | 0.83 | 0.70, 0.99 | |

Abbreviations: OR, odds ratio; RR, relative risk.

[a] Includes data from Denmark, France, Germany, Greece, Italy, the Netherlands, Spain, and Sweden.

**Table 2.** Frequency Distribution of Selected Characteristics Among Ovarian Cancer Case and Control Patients, African American Cancer Epidemiology Study, United States, 2010–2014

| Variable | Cases (n = 513) | | Controls (n = 721) | | OR[a] | 95% CI |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| Age, years[b] | | | | | | |
| 20–39 | | 5.5 | | 11.1 | | |
| 40–49 | | 17.0 | | 16.3 | | |
| 50–59 | | 33.9 | | 38.0 | | |
| 60–69 | | 26.9 | | 25.4 | | |
| 70–79 | | 16.8 | | 9.3 | | |
| Currently married | | | | | | |
| No | | 68.4 | | 58.5 | 1.00 | Referent |
| Yes | | 31.6 | | 41.6 | 0.64 | 0.50, 0.82 |
| Employed full-time | | | | | | |
| No | | 59.8 | | 66.9 | 1.00 | Referent |
| Yes | | 40.2 | | 33.2 | 1.69 | 1.30, 2.19 |
| Missing | 0 | | 1 | | | |
| Current insurance | | | | | | |
| Public | | 61.3 | | 53.1 | 1.00 | Referent |
| Private | | 38.7 | | 46.9 | 0.79 | 0.61, 1.01 |
| Missing | 45 | | 19 | | | |
| Region of residence | | | | | | |
| North | | 26.3 | | 31.6 | 1.00 | Referent |
| South | | 73.7 | | 68.4 | 2.29 | 0.72, 7.26 |
| Age at menarche, years | | | | | | |
| <12 | | 22.3 | | 26.0 | 0.85 | 0.63, 1.13 |
| 12–13 | | 52.0 | | 48.5 | 1.0 | Referent |
| ≥13 | | 25.8 | | 25.5 | 0.89 | 0.67, 1.19 |
| Missing | 1 | | 0 | | | |
| Parity (≥28-week pregnancy) | | | | | | |
| 0 | | 18.6 | | 12.8 | 1.00 | Referent |
| 1–2 | | 42.4 | | 45.4 | 0.61 | 0.43, 0.86 |
| ≥3 | | 39.0 | | 41.8 | 0.52 | 0.36, 0.75 |
| Missing | 3 | | 4 | | | |
| Tubal ligation | | | | | | |
| No | | 66.3 | | 59.9 | 1.00 | Referent |
| Yes | | 33.7 | | 40.1 | 0.70 | 0.55, 0.90 |
| Missing | 3 | | 4 | | | |
| Oral contraceptive use | | | | | | |
| No | | 29.8 | | 19.8 | 1.00 | Referent |
| Yes | | 70.2 | | 80.2 | 0.61 | 0.47, 0.81 |
| Oral contraceptive use, months | | | | | | |
| Never to <3 | | 35.5 | | 24.3 | 1.00 | Referent |
| 3–35 | | 25.9 | | 30.8 | 0.60 | 0.44, 0.82 |
| 36–59 | | 8.8 | | 10.7 | 0.60 | 0.39, 0.92 |
| ≥60 | | 29.8 | | 34.3 | 0.62 | 0.46, 0.83 |
| Missing | 0 | | 1 | | | |
| Menopausal status | | | | | | |
| Postmenopausal | | 73.1 | | 69.5 | 1.00 | Referent |
| Premenopausal | | 27.0 | | 30.5 | 1.58 | 1.10, 2.28 |
| Missing | 1 | | 1 | | | |
| Use of HRT among women >50 years of age | | | | | | |
| No | | 75.0 | | 79.0 | 1.00 | Referent |
| Yes | | 25.0 | | 21.0 | 1.17 | 0.85, 1.63 |
| First degree relative with ovarian and/or breast cancer | | | | | | |
| No | | 74.1 | | 81.6 | 1.00 | Referent |
| Yes | | 26.0 | | 18.5 | 1.50 | 1.12, 1.99 |
| Missing | 12 | | 23 | | | |
| Body mass index[c] 1 year before diagnosis | | | | | | |
| <24.9 | | 14.0 | | 18.6 | 1.00 | Referent |
| 25.0–29.9 | | 25.3 | | 26.2 | 1.20 | 0.82, 1.75 |
| 30.0–34.9 | | 27.5 | | 25.8 | 1.30 | 0.89, 1.89 |
| ≥35.0 | | 33.2 | | 29.4 | 1.44 | 1.00, 2.07 |
| Missing | 4 | | 1 | | | |

**Table continues**

Abbreviations: CI, confidence interval; HRT, hormone replacement therapy; OR, odds ratio.

[a] Adjusted for age and study site.

[b] Matching factor.

[c] Weight (kg)/height (m)$^2$.

be key potential confounding variables: body mass index, parity, family history of ovarian or breast cancer, tubal ligation, and history of oral contraceptive use, with the variables coded as presented in Table 2. Then both educational level and income were included in the same model to calculate mutually adjusted results. Participants with missing covariate data (a total of 67 cases and 48 controls) were dropped from the multiple regression models.

Odds ratios and 95% confidence intervals were estimated for each category of education and income compared with the referent category. Tests for trend across the ordered categories of these SES variables with risk of ovarian cancer were conducted by adding the SES variable as a single variable coded with the midpoint of each category and then calibrated to make the referent category zero. The $P$ value for trend was estimated based on the likelihood ratio test.

To assess the possible effect modification of the associations of educational level and income with ovarian cancer,

**Table 3.** Relative Odds of Ovarian Cancer According to Educational Level and Income, African American Cancer Epidemiology Study, United States, 2010–2014

| Socioeconomic Characteristic | % of Cases | % of Controls | Model 1[a] | | Model 2[b,c] | | Model 3[d,e] | |
|---|---|---|---|---|---|---|---|---|
| | | | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Educational level[f] | | | | | | | | |
| High school diploma or less | 46.2 | 37.0 | 1.00 | Referent | 1.00 | Referent | 1.00 | Referent |
| Some post-high school education | 30.2 | 36.1 | 0.73 | 0.55, 0.96 | 0.72 | 0.53, 0.96 | 0.78 | 0.57, 1.06 |
| College degree or more | 23.6 | 26.9 | 0.76 | 0.57, 1.03 | 0.71 | 0.51, 0.99 | 0.77 | 0.52, 1.14 |
| *P* for trend | | | 0.03 | | 0.02 | | 0.11 | |
| Educational level: dichotomous | | | | | | | | |
| High school diploma or less | 46.2 | 37.0 | 1.00 | Referent | 1.00 | Referent | 1.00 | Referent |
| Any post-high school education | 53.8 | 63.0 | 0.74 | 0.58, 0.95 | 0.72 | 0.55, 0.93 | 0.79 | 0.59, 1.06 |
| *P* value | | | 0.02 | | 0.01 | | 0.11 | |
| Total family income, $[g] | | | | | | | | |
| <10,000 | 22.9 | 20.4 | 1.00 | Referent | 1.00 | Referent | 1.00 | Referent |
| 10,000–24,999 | 25.7 | 23.8 | 0.90 | 0.63, 1.29 | 0.97 | 0.66, 1.41 | 0.99 | 0.68, 1.45 |
| 25,000–49,999 | 24.8 | 21.8 | 1.01 | 0.70, 1.45 | 1.02 | 0.70, 1.50 | 1.10 | 0.74, 1.64 |
| 50,000–74,999 | 13.1 | 17.2 | 0.65 | 0.43, 0.99 | 0.67 | 0.43, 1.04 | 0.76 | 0.47, 1.22 |
| ≥75,000 | 13.5 | 16.8 | 0.74 | 0.49, 1.12 | 0.74 | 0.47, 1.16 | 0.85 | 0.52, 1.40 |
| *P* for trend | | | 0.048 | | 0.055 | | 0.31 | |
| Income: dichotomous | | | | | | | | |
| <$25,000 | 48.6 | 44.2 | 1.00 | Referent | 1.00 | Referent | 1.00 | Referent |
| ≥$25,000 | 51.4 | 55.8 | 0.87 | 0.68, 1.11 | 0.86 | 0.66, 1.12 | 0.95 | 0.72, 1.27 |
| *P* value | | | 0.25 | | 0.25 | | 0.74 | |

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] Adjusted for age and study site.

[b] Adjusted for age, study site, body mass index, parity, family history of ovarian or breast cancer, tubal ligation, and history of oral contraceptive use.

[c] The education models were limited to 492 cases and 692 controls, and the income model was limited to 446 cases and 673 controls.

[d] Adjusted for age, study site, body mass index, parity, family history of ovarian or breast cancer, tubal ligation, history of oral contraceptive use, and educational level or income as appropriate.

[e] The income models were limited to 446 cases, 673 controls.

[f] There were 513 cases and 721 controls for this variable.

[g] There were 459 cases and 697 controls for this variable.

the following variables were selected a priori for stratified analyses: marital status, employment status, health insurance status, and region of residence. The rationale for including marital status, employment status, and health insurance was that these additional markers of SES may provide mechanistic insight into the nonstratified associations with educational level and income. The rationale for assessing the associations according to residence in the northern versus southern United States was that the broad differences in the overall social milieus between regions, such as the higher poverty rate and greater proportion of rural residents in the southern United States (13), make this an area-level measure that could potentially provide insights into the nonstratified associations. Residents of Michigan, New Jersey, and Ohio were classified as residing in the northern United States, and residents of Alabama, Georgia, Louisiana, North Carolina, South Carolina, Tennessee, and Texas were classified as residing in the southern United States. Potential interactions were formally assessed by using multiple logistic regression models that included the entire study population and calculating *P* values via the likelihood ratio test.

## RESULTS

Case-control comparisons of sociodemographic and lifestyle characteristics and ovarian cancer risk factors are summarized in Table 2. Ovarian cancer case patients tended to be slightly older than the controls despite the frequency matching by age. Within this study population, factors known to be associated with a higher risk of ovarian cancer, such as a positive family history of breast or ovarian cancer and increasing body mass index, were significantly associated with higher risk; likewise, factors known to be inversely associated with ovarian cancer risk, such as increasing parity, tubal ligation, and oral contraceptive use, were significantly inversely associated with risk. Some factors associated with greater SES were associated with lower ovarian cancer risk, such as being married and having private health insurance, whereas being employed full-time was associated with higher ovarian cancer risk.

**Table 4.** Relative Odds of Ovarian Cancer by Educational Level, Stratified by Marital Status, Employment Status, Medical Insurance, and Region of Residence, African American Cancer Epidemiology Study, United States, 2010–2014

| Variable | Level of Education | | | | | | | | *P* Value | *P* for Interaction |
|---|---|---|---|---|---|---|---|---|---|---|
| | High School Diploma or Less | | | | Some Post–High School Education | | | | | |
| | No. of Cases | No. of Controls | OR | 95% CI | No. of Cases | No. of Controls | OR | 95% CI[a,b] | | |
| Currently married | 225 | 253 | | | 267 | 439 | | | | 0.20 |
| No | 157 | 161 | 1.00 | Referent | 180 | 240 | 0.74 | 0.53, 1.04 | 0.08 | |
| Yes | 68 | 92 | 1.00 | Referent | 87 | 199 | 0.72 | 0.46, 1.11 | 0.14 | |
| Employed full-time | 225 | 253 | | | 267 | 439 | | | | 0.35 |
| No | 163 | 110 | 1.00 | Referent | 129 | 250 | 0.67 | 0.48, 0.92 | 0.02 | |
| Yes | 62 | 43 | 1.00 | Referent | 138 | 189 | 0.50 | 0.31, 0.82 | 0.006 | |
| Medical insurance | 205 | 245 | | | 247 | 432 | | | | 0.68 |
| None or public | 161 | 181 | 1.00 | Referent | 113 | 179 | 0.64 | 0.45, 0.91 | 0.01 | |
| Private or other | 44 | 64 | 1.00 | Referent | 134 | 253 | 0.82 | 0.51, 1.32 | 0.42 | |
| Region of residence | 214 | 232 | | | 267 | 439 | | | | 0.48 |
| North | 41 | 65 | 1.00 | Referent | 86 | 153 | 0.96 | 0.56, 1.67 | 0.90 | |
| South | 173 | 167 | 1.00 | Referent | 181 | 286 | 0.65 | 0.48, 0.89 | 0.006 | |

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] Adjusted for age, study site, body mass index, parity, family history of ovarian or breast cancer, tubal ligation, and history of oral contraceptive use.
[b] The total number included in the models was 513 cases and 721 controls except for medical insurance models, which included 468 cases and 702 controls.

The associations of ovarian cancer risk according to levels of education and income are summarized in Table 3. The frequency distributions of education and income represent a spectrum of SES groups, with 37% of controls having a high school diploma or less and 27% with a college degree or more and with 20% of controls having a total annual family income less than \$10,000 and 17% having an income of \$75,000 or more. After adjustment for age, study site, body mass index, parity, family history of ovarian or breast cancer, tubal ligation, and history of oral contraceptive use, compared with those with a high school education or less, those with some education after high school but less than a college degree had an odds ratio of 0.72 (95% confidence interval (CI): 0.53, 0.96), and those with a college degree or more had an odds ratio of 0.71 (95% CI: 0.51, 0.99; *P* for trend = 0.02). For the dichotomous comparison of a high school diploma or less education versus any post–high school education, the adjusted odds ratio was 0.72 (95% CI: 0.55, 0.93). After adjustment for the same factors, the odds ratios were 0.97 (95% CI: 0.66, 1.41), 1.02 (95% CI: 0.70, 1.50), 0.67 (95% CI: 0.43, 1.04), and 0.74 (95% CI: 0.47, 1.16) for those with family annual incomes of \$10,000–\$24,999, \$25,000–\$49,999, \$50,000–\$74,999, and ≥\$75,000, respectively, when compared with those with a family annual income of less than \$10,000 (*P* for trend = 0.055). For the dichotomous comparison of an income less than \$25,000 versus an income of \$25,000 or more, the adjusted odds ratio was 0.86 (95% CI: 0.66, 1.12). For both educational level and income, the age- and study site–adjusted results were almost identical to the more fully adjusted results.

When the education results were adjusted for income level, the odds ratios were attenuated to 0.78 (95% CI: 0.57, 1.06) and 0.77 (95% CI: 0.52, 1.14), and the trend test was no longer statistically significant (*P* for trend = 0.11) (Table 3, model 3). When the income results were adjusted for education, the association between income and ovarian cancer risk was attenuated as evidence by a test-for-trend *P* value of 0.31 compared with the model 2 *P* value of 0.055 (Table 3, model 3).

To assess the potential effect modifiers of the associations characterized above, we stratified the analyses by marital status, employment status, health insurance status, and region of residence to examine the associations of ovarian cancer risk with educational level (Table 4) and income (Table 5). The odds ratios for the association between educational level and ovarian cancer were in the inverse direction in all of the subgroups defined by these variables, with no strong evidence of interaction (all *P* for interaction ≥0.20) (Table 4). The associations were consistent within categories of marital status (for married women, odds ratio (OR) = 0.72, 95% CI: 0.46, 1.11; for unmarried women, OR = 0.74, 95% CI: 0.53, 1.04), employment status (for women employed full time, OR = 0.50, 95% CI: 0.31, 0.82; for women not employed full time, OR = 0.67, 95% CI: 0.48, 0.92), and medical insurance (for women with private medical insurance, OR = 0.82, 95% CI: 0.51, 1.32; for women with other/public insurance or no insurance, OR = 0.64, 95% CI: 0.45, 0.91) (Table 4). With respect to region of residence, the odds ratios suggested a stronger inverse association in the southern states (OR = 0.65, 95% CI: 0.48, 0.89) as compared with the northern states (OR = 0.96, 95% CI: 0.56, 1.67), but the *P* for interaction was not statistically significant.

Consistent inverse associations between income and ovarian cancer were present in almost all of the subgroups.

**Table 5.** Relative Odds of Ovarian Cancer by Income, Stratified by Marital Status, Employment Status, Medical Insurance, and Region of Residence, African American Cancer Epidemiology Study, United States, 2010–2014

| Variable | Annual Family Income | | | | | | | | *P* Value | *P* for Interaction |
|---|---|---|---|---|---|---|---|---|---|---|
| | <\$25,000 | | | | ≥\$25,000 | | | | | |
| | No. of Cases | No. of Controls | OR | 95% CI | No. of Cases | No. of Controls | OR | 95% CI[a,b] | | |
| Currently married | 214 | 297 | | | 232 | 376 | | | | 0.11 |
| No | 166 | 229 | 1.00 | Referent | 133 | 161 | 1.03 | 0.73, 1.44 | 0.88 | |
| Yes | 48 | 68 | 1.00 | Referent | 99 | 215 | 0.70 | 0.43, 1.13 | 0.15 | |
| Employed full-time | 214 | 297 | | | 232 | 376 | | | | 0.02 |
| No | 158 | 261 | 1.00 | Referent | 100 | 183 | 0.84 | 0.60, 1.19 | 0.33 | |
| Yes | 56 | 36 | 1.00 | Referent | 132 | 193 | 0.38 | 0.23, 0.64 | <0.001 | |
| Medical insurance | 213 | 295 | | | 232 | 376 | | | | 0.16 |
| None or public | 178 | 249 | 1.00 | Referent | 91 | 107 | 0.96 | 0.66, 1.40 | 0.82 | |
| Private or other | 35 | 46 | 1.00 | Referent | 141 | 269 | 0.72 | 0.43, 1.20 | 0.20 | |
| Region | 214 | 297 | | | 232 | 376 | | | | 0.81 |
| North | 41 | 77 | 1.00 | Referent | 65 | 132 | 0.74 | 0.42, 1.30 | 0.30 | |
| South | 173 | 220 | 1.00 | Referent | 167 | 244 | 0.88 | 0.65, 1.19 | 0.41 | |

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] Adjusted for age, study site, body mass index, parity, family history of ovarian or breast cancer, tubal ligation, and history of oral contraceptive use.

[b] The total number included in the models was 513 cases and 721 controls except for medical insurance models, which included 468 cases and 702 controls.

Stronger inverse associations were observed among those who were employed (OR = 0.38, 95% CI: 0.23, 0.64), were married (OR = 0.70, 95% CI: 0.43, 1.13), and had private health insurance (OR = 0.72, 95% CI: 0.43, 1.20) (Table 5). The association between income and ovarian cancer risk was consistently more strongly in the inverse direction in those subgroups that are markers of higher SES, but the formal tests for interaction were statistically significant only for employment status (*P* for interaction 0.02).

## DISCUSSION

In the present population-based, case-control study in which we assessed the association between SES and ovarian cancer in African-American women, the findings suggested that higher levels of education were associated with lower ovarian cancer risk. The inverse association between educational level and ovarian cancer was evident after adjustment for ovarian cancer risk factors and income and was relatively consistent across categories of marital status, employment status, insurance, and region of residence. The associations for income were not as straightforward as those for education but hinted at the possibility that the highest income levels were inversely associated with ovarian cancer risk. However, in stratified analyses, a consistent inverse association between income and ovarian cancer risk was observed for those who were employed, were married, and had private health insurance, that is, those in groups that tend to be of higher SES. Thus, for income, the nonstratified associations were equivocal, whereas the subgroup analyses raised the possibility that income was inversely associated with ovarian cancer risk in groups that are more likely to be of higher SES. Although the underlying reasons for this pattern of associations are uncertain, the results suggest that the influence of higher income may be enhanced in the presence of other favorable SES indicators.

Considered in combination, the evidence within this study population hints that lower SES may be associated with a higher risk of ovarian cancer, although the study inferences need to be tempered by the fact that the results did not unequivocally point in this direction. Specifically, the associations of educational level and income with ovarian cancer risk did not reveal clear dose-response trends, and many of the associations were not statistically significant. Despite the lack of complete internal consistency in the inverse association between measures of SES and ovarian cancer, considered in the context of prior evidence on this topic (Table 1), it is notable that the observed associations in the present study were in the protective rather than risk direction. One could hypothesize that based on some similarities in their epidemiologic risk factor profiles, ovarian cancer would follow the pattern seen for breast cancer (another hormonally driven cancer), for which higher SES is associated with higher disease risk. In several prior studies, but in only 1 conducted in the United States, investigators have observed associations in the direction of higher SES being associated with higher ovarian cancer risk (5, 8, 9, 11), but these associations have often been weak and not statistically significant. The ambiguity in the evidence is also illustrated by the heterogeneity in the results of prospective cohort studies (12–14). Against this backdrop, the results of the present study add evidence to suggest the possibility of an inverse association between SES and ovarian cancer.

When placing the present study in the context of prior evidence on this topic, it is worth keeping its unique features in mind. First, this is the second US case-control in which the association between SES and ovarian cancer has been reported and the first in which the association has been reported in African-American women. Second, the spectrum of SES within this study population merits consideration. In US women, there are well-documented socioeconomic differences by race. Compared with black women, white women are more likely to have a college degree or more education (28% vs. 19%) and a total family annual income of $75,000 or more (41% vs. 23%); however, they are less likely to have an income less than $10,000 (4% vs. 11%) (16, 17). The case patients with ovarian cancer in the present study population had educational levels similar to the national distribution among US African-American females published by the US Census Bureau (16, 17), whereas the controls had a higher level of education (i.e., 27% vs. 21% with a college degree or more). In contrast, on average, both the case and control participants in the present study had lower total family annual income levels than did African-American women in the United States. For example, 11% of US African-American females have incomes of $10,000 or less, compared with 20% of AACES control participants; conversely, 23% of US African-American females have incomes of $75,000 or higher, compared with 17% of AACES control participants (16, 17).

If SES is truly inversely associated with ovarian cancer risk, the reasons for this association remain to be characterized. One possibility is that the association is mediated through lifestyle factors. Cigarette smoking has not been linked to ovarian cancer risk overall, but it has been linked specifically to mucinous ovarian cancer (18). There is some evidence, albeit less than clear-cut, that more physical activity (19, 20) and greater consumption of nonstarchy vegetables (21) are inversely associated with ovarian cancer risk. Higher SES is associated with healthier diets and increased levels of physical activity (22), so this provides a tenable—but unproven—scenario that aligns with the observed data.

Alternative explanations for the results also need to be considered. The observed findings are unlikely to be due to reverse causation, that is, the ovarian cancer symptoms and diagnosis leading to a decrease in SES. Strong evidence against this possibility is that the most consistent associations were observed for educational level, which unlike income is not affected by this potential explanation (1).

Regarding the potential for the findings of the present study to be spurious, information bias is unlikely to have had a major influence on the study findings because measurement error with respect to SES measures was likely to be nondifferential with respect to case-control status. However, selection bias poses a legitimate concern. The cooperation rate among those contacted was 67% among ovarian cancer case patients and 72% among control participants, but 15% of ascertained case patients had already died before they could be recruited into AACES, and another 12% were unable to be contacted for other reasons (15). Lower SES is associated with worse rates of survival from ovarian cancer (23). If the cases of rapidly fatal ovarian cancer prior to study entry among potential participants occurred among those who were also likely to be of lower SES, this would result in the case patients that were actually included being of higher SES than if the fatal cases had been included and thus would bias a true inverse association toward the null. A similar argument could also apply to ovarian cancer patients who were unable to be contacted. Thus, the associations actually observed in the present study may represent overly conservative estimates of the inverse association compared with what would have been observed if more complete case enrollment had been achieved. Another inferential issue to consider is that the lack of racial diversity in the AACES population precludes having internal comparisons with other racial/ethnic groups that would have provided valuable contextual information for interpreting the evidence provided by this study.

Strengths of the present study were that it was a population-based, case-control study that followed a detailed protocol for rapid case ascertainment and recruitment of controls matched by age and region. With 513 cases and 721 controls, it is one of the largest studies of SES in relation to ovarian cancer risk to date, and it is also among the most thorough in its assessment of SES factors. There is no previously published evidence of an association between SES and ovarian cancer in African-American women, so this study provides novel evidence on this topic. The wide geographic area covered by this study adds a degree of generalizability that is uncommon in studies of this type.

In conclusion, these findings suggest that ovarian cancer risk may be inversely associated with SES among African-American women based on the observations that 1) higher levels of education were inversely associated with ovarian cancer risk and 2) individuals with the highest income level had a nonsignificantly lower risk than did those with the lowest income level. Further study is clearly needed to strengthen our understanding of the potential association between SES and ovarian cancer. An ovarian cancer case-control study of this size focused on African-American women is unlikely to be replicated; this accentuates the need to clarify the association between SES and ovarian cancer within women of European ancestry, for whom extensive data is likely to have already been collected in prior studies.

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